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Incidence, predictors and early outcomes of acute kidney injury among patients undergoing abdominal surgery at Bugando Medical Centre, Mwanza, Tanzania

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Abstract
Background: Acute kidney injury (AKI) is a frequent occurrence following major surgery and is independently associated with high morbidity and mortality. Data regarding AKI following abdominal surgery is limited in sub-Saharan Africa and Tanzania in particular. This study aimed to determine the incidence, predictors and early outcome of AKI among patients undergoing abdominal surgery at Bugando Medical Centre (BMC).
Methods: This was a longitudinal study to determine the incidence, predictors and early outcome of acute kidney injury among patients undergoing abdominal surgery at BMC between March 2022 and July 2022.
Results: 172 patients were studied (M: F= 1.1: 1). The overall median age of patients at presentation was 34 years. Forty-six (26.7%) patients developed AKI postoperatively. Among the patients who had AKI, 30(65.2%) were classified as KDIGO stage 1, 12 (20.1%) as stage 2 and 4 (8.7%) as stage 3. On multivariate analysis, the age ≥45 years (p=0.036), pre-existing medical illness (p=0.015), pre-existing renal dysfunction (p= 0.007), duration of surgery (p=0.007) and emergency surgery (p= 0.001) were the main predictors of postoperative AKI. The overall median length of the hospital was 8.7 days, and the overall mortality rate was 5.8%. The mortality rate among patients with AKI was significantly high compared to patients without AKI (15.2% v/s 2.4%; p= 0.020). Postoperative AKI was independently considerably associated with prolonged length of hospital stay (p= 0.001) and mortality (p=0.020). Recovery was observed in 63% of patients who developed postoperative AKI.
Conclusion: AKI incidence is high among patients undergoing abdominal surgery at BMC and is associated with high mortality and increased LOS. Prompt identification and aggressive treatment of postoperative AKI risk factors offer the potential to reduce the burden of AKI in this group of patients.

Keywords: Acute kidney injury incidence, predictors, early outcome, abdominal surgery, Tanzania

Introduction

Acute kidney injury (AKI) is a clinical syndrome that primarily presents as a rapid decline in kidney filtration function that results in the retention of urea and other nitrogenous waste products, deregulation of extracellular volume and electrolytes (Mehta *et al*., 2007; Lewington *et al*., 2013). AKI is a significant cause of morbidity and mortality among patients undergoing major surgical interventions worldwide and contributes to prolonged hospital stays and increased cost of treatment

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(Bellomo *et al.,* 2012). The epidemiology of AKI appears different between high-income countries (HICs) and low- and middle-income countries (LMICs) (Priyamvada *et al*.,2018). Whereas it is often seen following major cardiac surgery in the former, this is not the case in LMICs) Priyamvada *et al*.,2018; Melfd *et al*., 2020) .

Globally, surgery remains a leading cause of AKI in hospitalized patients, accounting for up to 40% of in-hospital AKI cases. The rate of AKI in this group of patients is variable, depending on the surgical setting and the AKI definition used) Uchino., 2005). The highest rates are found after cardiac surgery, followed by general and thoracic surgeries (Thakar.,2013; Grams *et al*., 2016). In Sub-Saharan Africa (SSA), the outcome of patients with AKI is very poor, with an overall mortality of 32% in adults. This is extremely high compared to the pooled world mortality of 23.9%. This mortality increases with the severity of AKI, which is estimated at 50–60% amongst patients requiring renal replacement therapy (RRT) and 82% in those in need of dialysis who could not receive it) Jha & Parameswaran., 2013). This high mortality in SSA is due to the late presentation of patients with severe disease in the hospital, the non-availability of RRT and the inability to afford treatment as health care costs are covered by out-of-pocket payment in most SSA countries) Jha & Parameswaran., 2013; Olowu *et a*l., 2016). Most of the reports from the SSA region are on community-acquired AKI, while reports on the epidemiology of AKI among individuals undergoing surgery are limited. With the increase in the volume of surgical procedures performed in SSA) Jha & Parameswaran., 2013; Olowu *et a*l., 2016 Cerdá *et al.,* 2017), it has been hypothesized that most cases of surgery-related AKI are under-detected. The impact of delayed or undetected AKI is enormous in patients undergoing surgical interventions, and it is associated with increased morbidity and mortality, prolonged hospital stays and higher cost of treatment) Cerdá *et al.,* 2017).

Although numerous strategies have been reported to prevent and treat AKI, the incidence of AKI is still increasing (Jha & Parameswaran., 2013; Cerdá *et al.,* 2017). Current literature on AKI is mainly from developed countries with well-established early AKI detection and management programs (Olowu *et a*l., 2016). In contrast, there is limited data on AKI from developing countries, representing over 85% of the world's population (Olowu *et a*l., 2016; Cerdá *et al.,* 2017). Despite perioperative AKI being a preventable disease with enormous benefits of early detection and intervention, which is feasible through the identification of risk factors and prompt institution of appropriate treatment during the peri-operative period, very limited data are available on the magnitude of AKI and its risk factors among patients undergoing surgery in the SSA and Tanzania in particular. This study aims to determine the incidence, predictors and early outcomes of AKI among patients undergoing abdominal surgery at Bugando Medical Centre

Methods

Study design and setting

This longitudinal study determined the incidence, predictors, and early outcomes of acute kidney injury among patients undergoing abdominal surgery at BMC between February 2022 and June 2022. BMC is a consultant, tertiary care, and teaching hospital for the Catholic University of Health and Allied Sciences (CUHAS) with 960 beds. The hospital is located in Mwanza City, in northwestern Tanzania. It serves as a referral centre for tertiary specialist care for a catchment population of approximately 17 million people from neighbouring regions.

Study population, sample size estimation, sampling procedure and study variables

The study population included all patients aged 18 and above undergoing abdominal surgery at BMC during the study period. All patients aged 18 years and above who underwent abdominal surgery at BMC during this study and were willing to participate after signing an informed consent form were

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included. Patients with pre-existing end-stage renal disease and those on dialysis or living with a functioning transplanted kidney were excluded from the study. Patients who experienced polytrauma, or abdominal trauma where the kidney was involved in the trauma, were also excluded from the study. The minimum sample size of this study was calculated using Daniel's formula for proportion as follows: $n = Z^2 \times p(1-p)/e^2$. Where n = the sample size; Z = standard error associated with the chosen level of precision (1.96); e = the level of precision = 0.5; p is the proportion of patients developed post-operative AKI in the study by Lugazia *et al* (2022) in Tanzania, which was 12.8%; Hence, $n = 1.96^2 x0.128x(1-0.128)/0.05^2 = 171$.

The estimated minimum sample size was 171 patients 10% (loss to follow-up) = 188 patients. Convenience sampling was performed to include all patients who met the inclusion criteria within the study period. All patients enrolled in the study were assessed preoperatively, intraoperatively, and postoperatively. Preoperative assessments were done on all patients, including a detailed history, physical examination, and relevant investigations. Blood samples were taken for serum creatinine, measured at the BMC laboratory. Creatinine was measured using the Jaffe kinetic method with a spectrophotometer (BIOMERIEUXVR, FRANCE). The initial serum creatinine was taken upon enrollment to determine the baseline upon admission.

Creatinine measurement was subsequently repeated for study purposes within 48 hours (day 2) after surgery and within 7 days of surgery to diagnose AKI. For patients with AKI, serum creatinine assay was repeated on discharge and day 30. Other routine preoperative investigations were done according to BMC protocol, including haemoglobin levels, packed cell volume, serum electrolytes, blood grouping and cross-matching. In addition, all patients were requested to test for HIV infection according to the National AIDS Control Program. Radiological investigations, including chest X-ray, abdominal X-ray, abdominal Ultrasonography, and abdominal CT scan, were done following the hospital routine if required to reach the correct diagnosis. AKI was diagnosed and staged according to the Kidney Disease Improving Global Outcomes (KDIGO) criteria (KDIGO., 2012). In brief, AKI is defined by an absolute increase in serum creatinine (SCr) by 0.3 mg/dL (26.4μmol/L) within 48 h of admission or an increase in SCr ≥ 1.5 times from baseline within 7 days. KDIGO definition will also be used to classify AKI into 3 stages based on serum creatinine (SCr) as follows: -

- Stage 1: SCr 1.5–1.9 times baseline;
- Stage 2: SCr 2.0–2.9 times baseline;
- Stage 3: SCr 3 times baseline, increases in SCr >4md/dl or (353.6umol/l), or initiation of haemodialysis.

Patients scheduled for emergency surgery were admitted through the emergency department after thorough resuscitation, and patients scheduled for elective surgery were admitted a day before surgery through the surgical outpatient clinic. All patients scheduled for surgery were assessed for fitness for surgery and anaesthesia. Haemodialysis was done when indicated. Postoperatively, all patients were followed until they were discharged from the hospital.

Independent (predictor) variables recorded in this study included patient-related (age, sex), associated medical illness, pre-existing sepsis, use of nephrotoxic drugs, use of IV contrast); laboratory characteristics (serum creatinine levels, haemoglobin levels, HIV status); operative characteristics (type of surgical procedure performed, the rank of the operator/surgeon, duration of surgery, hemodynamic instability, requirement of blood transfusion) and procedure-related complications: (E.C.F, sepsis). Dependent (outcome) variables were recorded as complete recovery from AKI, in-patient mortality, renal recovery, need for haemodialysis therapy and length of hospital stay. Complete (full) recovery from ARF was declared when renal function returned to normal range.

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Data management

Data collection

Data were collected using a standardized, pre-tested, and coded questionnaire. The collected data were entered into a computer using Epi-data version 3.1 (CDC, Atlanta, USA) and analysed using STATA version 15 (College Station, Texas, USA).

Statistical data analysis

Data were summarized in proportions and frequent tables for categorical variables. For continuous variables, data were reported as mean ± standard deviation (SD) or median ± inter-quartile range (IQR) depending on their distribution. Odds ratio (OR) with a 95% confidence interval (CI) was calculated to test for the strength of association between predictor and outcome variables using univariate analysis followed by multivariate logistic regression analyses for all predictors found to be significant on the univariate analysis. Significant association was defined as a p-value of less than 0.05.

Data quality control

To ensure the internal validity of the study, the following precautions were taken into consideration: -

- The data-collecting tool was pre-tested.
- Research assistants were trained to administer the questionnaire and collect data.
- the principal investigator ensured completeness and consistency and edited the data collected.

Results

Number of patients recruited in the study

During the study period, a total of 178 patients underwent abdominal surgeries at BMC due to different indications. Among these, 175 patients were recruited for enrolment in the study. Three patients were excluded from the study due to failure to meet the inclusion criteria. Thus, 172 patients were available for the final analysis, as shown in Figure 1 below

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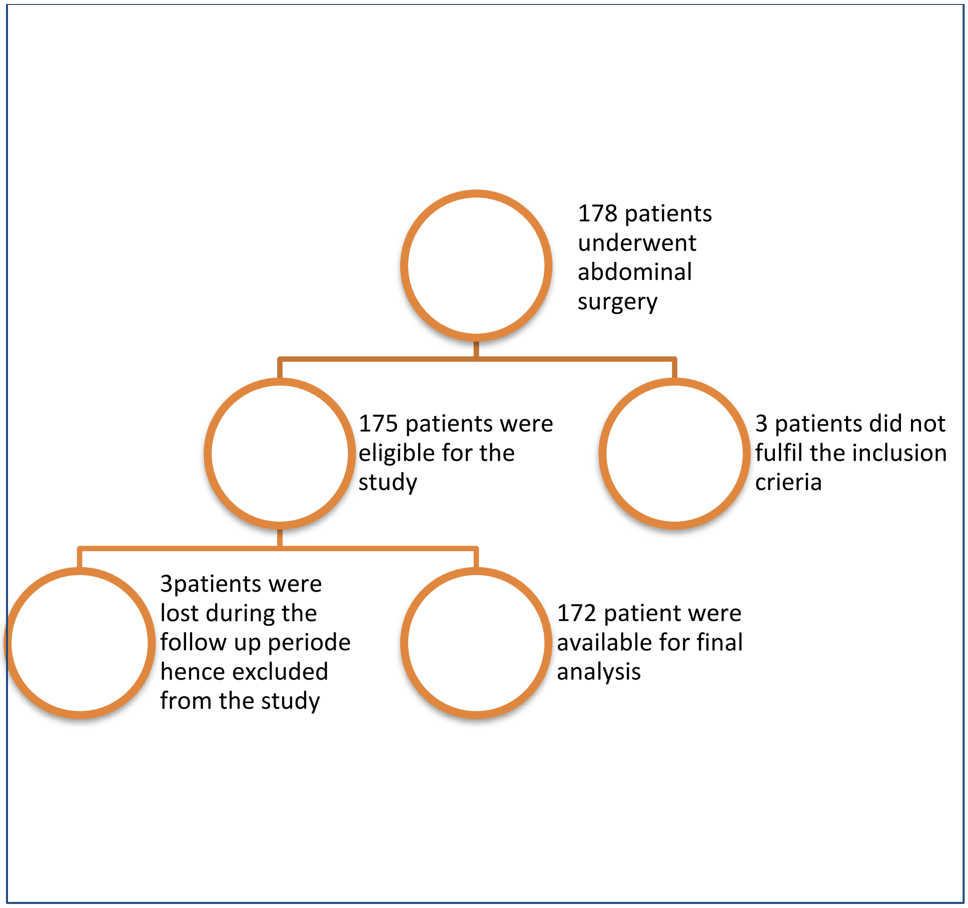

Figure 1: Flow diagram of patients recruited in the study

Socio-demographic and clinical characteristics of patients
The youngest patient was 18 years old, and the oldest was 76 years old. The overall median age of patients at presentation was 34 [IQR: 12-38] years. The modal age group at presentation was 31–40 years, accounting for 32.6% of cases (Figure 2). One hundred and twenty-six (73.3%) patients were aged 45 years and below. Of 172 patients, 91 (52.9%) were males, and 81 (47.1%) were females, giving a male-to-female ratio of 1.1: 1. More than half of the patients came from rural areas. Associated pre-existing medical illnesses were reported in 20(11.6%) cases (Figure 3).

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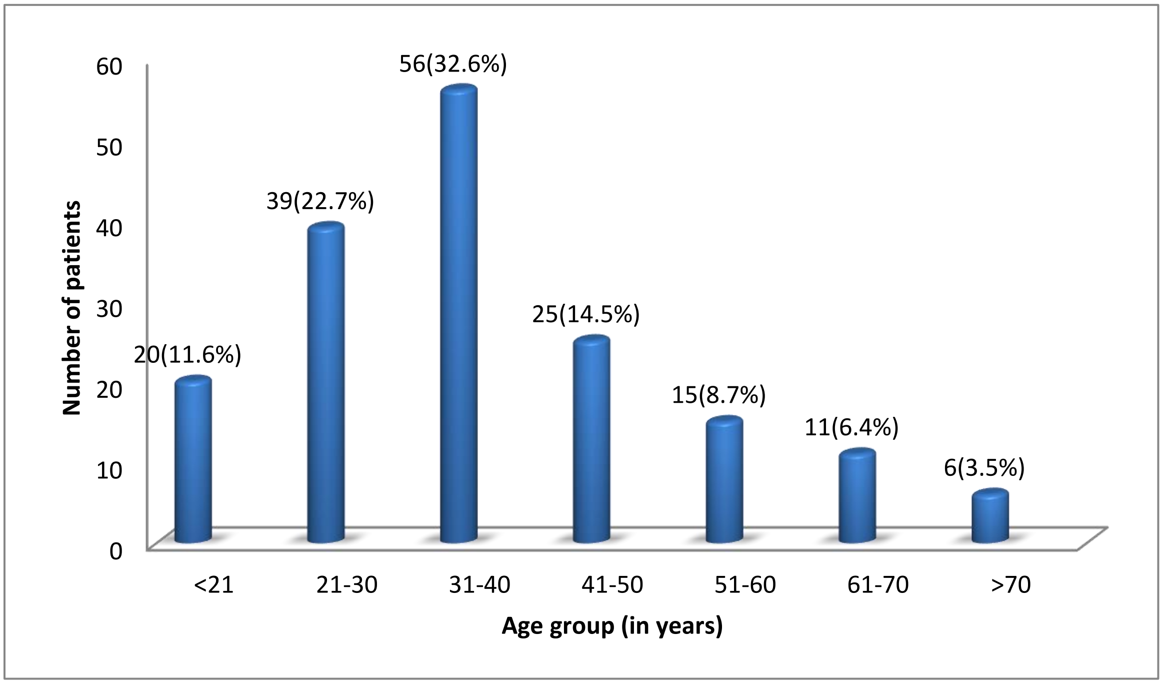

Figure 2: Age group distribution among patients who underwent abdominal surgeries at BMC

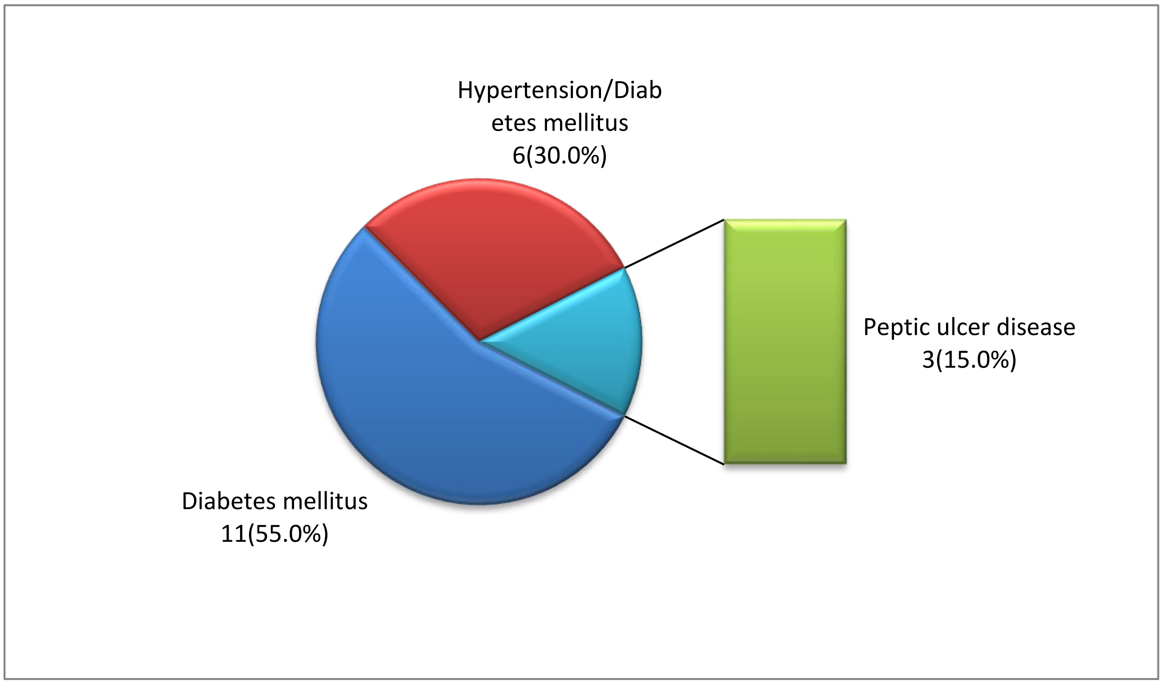

Figure 3: Distribution of patients according to pre-existing medical illness

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Table 1: Sociodemographic and clinical characteristics of patients

Patient characteristics	Number (n= 172)	Percent (%)
Gender		
Male	91	52.9
Female	81	47.1
Residence		
Urban	85	49.4
Rural	87	50.6
Employment		
Employed	79	45.9
Unemployed	93	54.1
Pre-existing medical illness		
Present	20	11.6
Not present	152	160.4
HIV infection		
Infected	12	7.0
Not infected	157	91.3
Unknown	3	1.7

Preoperative and intra-operative characteristics

Out of 172 patients who underwent abdominal surgery, 93 (54.1%) underwent elective surgery, while 79(45.9%) had emergency surgery (Table 2) for intestinal perforation with peritonitis in 40(23.3%) patients and intestinal obstruction in 27(15.7%) (Figure 4). Bowel resection and stoma formation were the most common surgical procedures, accounting for 22.0% of cases (Figure 5). Table 3 below shows pre-operative creatinine, haemoglobin, and WBC. Most patients, 95(55.2%), had the surgery duration lasting more than 2 hours (Table 5).

Table 2: Preoperative characteristics of patients undergoing abdominal surgery

Variables	Number of patients (N 172)	Percentage (%)
Nature of surgery		
Emergency	79	45.9
Elective	93	54.1
Duration of illness		
Less than 48hrs	84	48.8
More than 48hrs	88	51.2
Use of nephrotoxic drug		
No	147	85.5
Yes	25	14.5
Preexisting sepsis		
No	152	88.4
Yes	20	11.6

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Table 3: Pre-operative serum creatinine, haemoglobin and WBC

Variable	Number (n =172)	Percent (%)
Serum Creatinine (µmol/l)		
Normal (62-106)	135	78.4
High>106	37	21.5
Haemoglobin (g/dl)		
Normal (10 and above)	124	72.0
Low (<10)	48	27.9
WBC		
Normal (<12)	96	55.2
high (>12)	76	44.7

Table 4: Intra-operative characteristics of patients undergoing abdominal surgery

Variables	Number of patients (N= 172)	Percentage (%)
Duration of surgery		
Less than 2hrs	77	44.8
More than 2hrs	95	55.2
Rank of Operator		
Senior (Surgeon)	147	85.5
Junior (registrar / Resident)	25	14.5
Type of anaesthesia		
GA	153	88.9
SAB	19	11.1
Blood transfusion		
No	145	84.3
Yes	27	15.7

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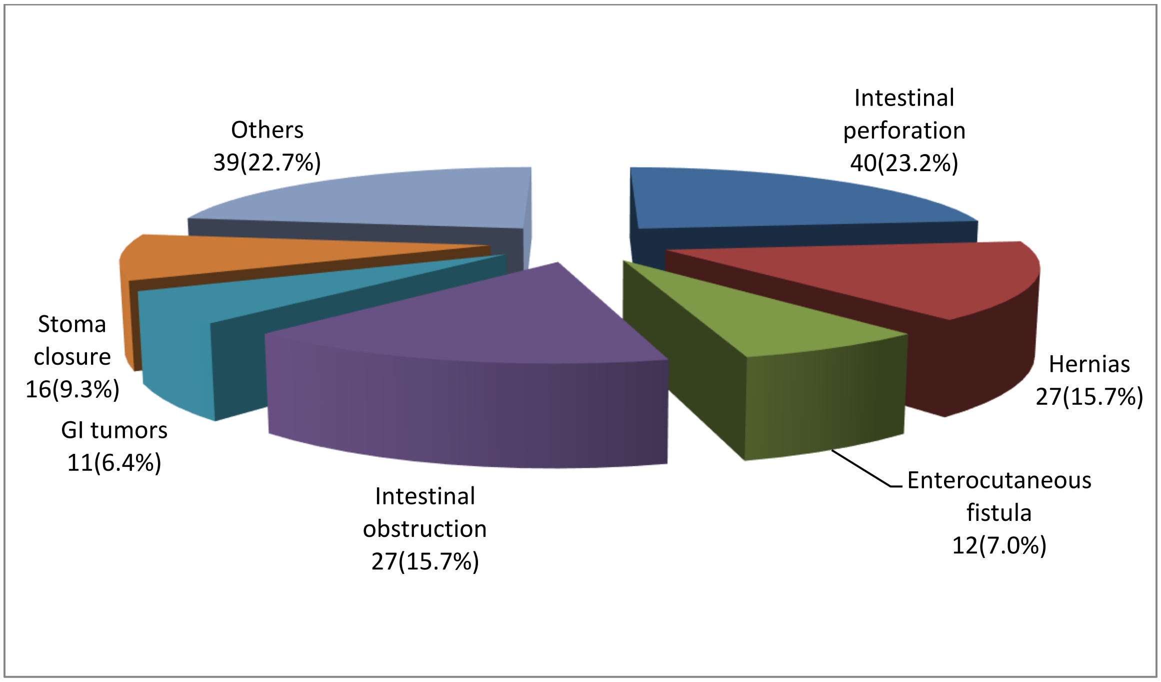

Figure 4: Distribution of patients according to indications for surgery

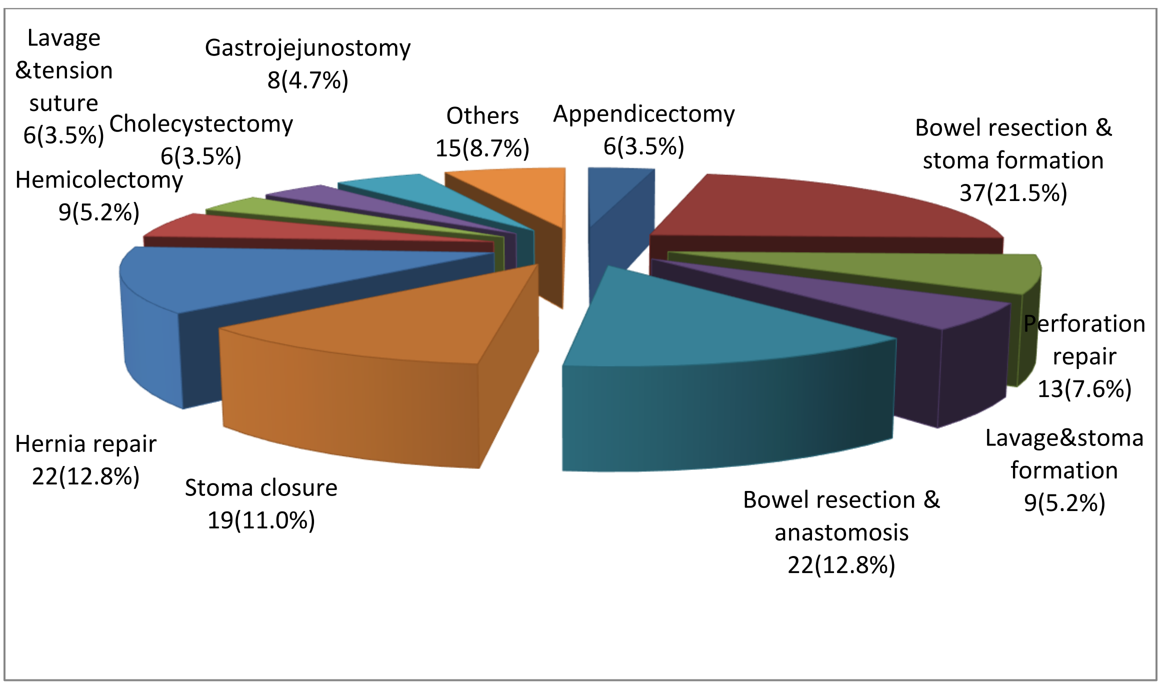

Figure 5: Distribution of patients according to the type of surgery performed

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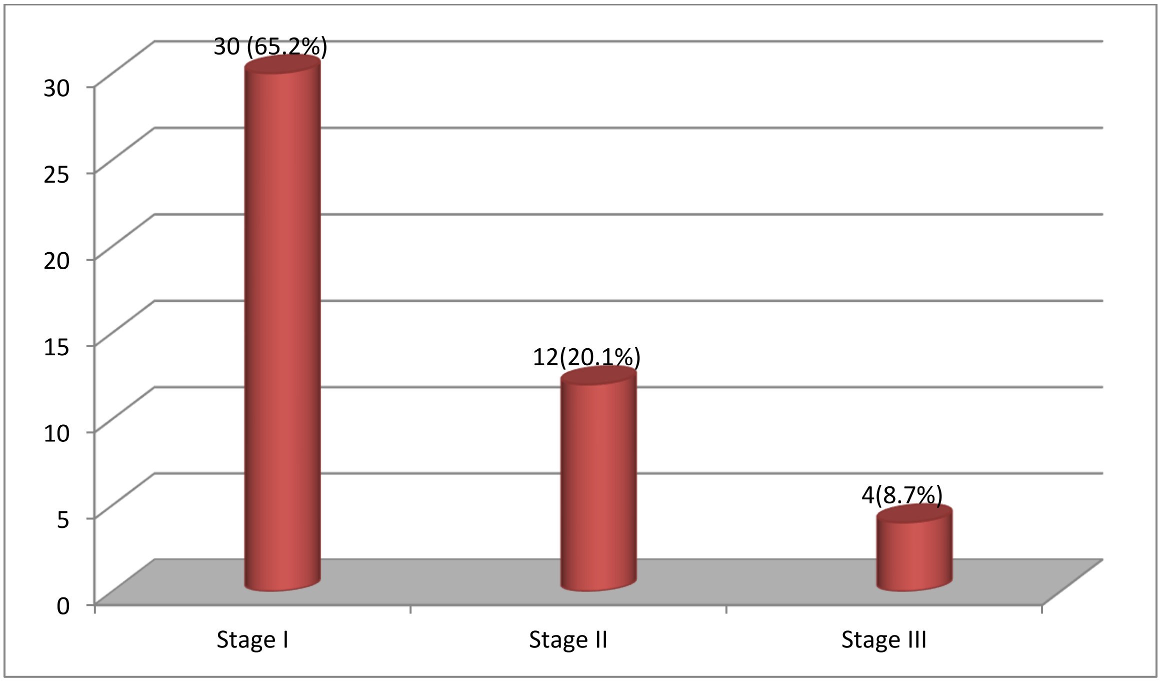

Figure 6: KDIGO grading among patients with AKI

Incidence and predictors of AKI

Out of 172 recruited patients, 46(26.7%) developed AKI postoperatively. The severity of AKI using KDIGO grading shows that the majority of patients had stage I, accounting for 65.2% of cases (Figure 6). Table 6 below shows predictors of postoperative AKI according to univariate analysis. On multivariate analysis, the age ≥45 years (p=0.036), pre-existing medical illness (p=0.015), pre-existing renal dysfunction (p= 0.007), duration of surgery (p=0.007) and emergency surgery (p= 0.001) were the main predictors of postoperative AKI (Table 7).

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Table 5: Predictors of postoperative AKI according to univariate analysis

Variables	No of pts with AKI	No of pts without AKI	Odds ratio (95% CI)	p-value
Gender				
Female	21(25.9)	60(74.1)	1	
Male	25(27.5)	66(72.5)	1.08(0.54- 2.13)	0.819
Age				
<45	27 (21.4)	99(78.6)	1	
≥ 45	19(41.3)	27(58.7)	2.79(1.30-5.60)	0.007
Pre-existing illness				
Absent	33(21.7)	119(78.3)	1	
Present	13(65.0)	7(35.0)	6.69(2.41-18.1)	<0.001
HIV status				
Positive	2(16.7)	10(83.3)	1	
Negative	44(27.5)	116(72.5)	1.89(0.39- 9.00)	0.421
Duration of illness				
<48hrs	9(10.7)	75(89.3)	1	
>48hrs	37(42.1)	51(57.9)	6.04(2.68- 13.5)	<0.001
Use of nephrotoxic drug				
Yes	5(26.3)	14(73.7)		
No	41(26.8)	112(73.2)	1.02(0.34- 3.02)	0.964
Pre-existing sepsis				
No	17(17.0)	83(83.0)	1	
Yes	29(40.3)	43(59.7)	3.29(1.63-6.64)	0.001
Preoperative creatinine				
Normal	26(19.3)	109(80.7)	1	
Elevated	20(54.1)	17(45.9)	4.93(2.27- 10.70)	<0.001
Hb level				
<10	22(45.8)	26(54.2)	1	
>10	24(19.3)	100(80.7)	0.28(0.14-0.58)	0.001
Rank of operator				
Senior	45(30.6)	102(69.4)	1	
Junior	1(4.0)	24(96.0)	0.09(0.01-0.72)	0.023
Timing of surgery				
Emergency	35(44.3)	44(55.7)	1	
Elective	11(11.8)	82(88.2)	0.17(0.07-0.36)	<0.001
Duration of surgery				
<2hrs	12(15.6)	65(84.4)	1	
>2hrs	34(35.8)	61(64.2)	3.01(1.43- 6.36)	0.004
Intra-operative BT				
No	33(22.8)	112(77.2)	1	
Yes	13(48.2)	14(51.8)	3.15(1.34- 7.36)	0.008

Table 6: Predictors of postoperative AKI according to Multivariate logistic regression analysis

Variables	Odds Ratio	95% Confidence interval	p-value
Age ≥45 years	2.37	1.78-20.14	**0.036**
Pre-existing medical illness	5.90	1.41-24.61	**0.015**
Pre-existing sepsis	1.02	0.34-3.05	0.960
Duration of illness	1.67	0.60-4.57	0.318
Preoperative haemoglobin levels	0.47	0.15-1.46	0.196
Pre-existing renal dysfunction	3.82	1.44-10.17	**0.007**
Intraoperative blood transfusion	1.77	0.51-6.11	0.363
Duration of surgery	4.49	1.50-13.43	**0.007**
Rank of operator	0.18	0.18- 1.86	0.153
Emergency surgery	0.13	0.04-0.46	**0.001**

Outcomes of patients

The overall LOS ranged from 1 day to 50 days with a median duration of 8.7[IQR, 2.8 -11.7] days. In this study, ten patients died, giving a cumulative mortality rate of 5.8%. The mortality rate among patients with AKI was high compared to patients without AKI (15.2% [i.e. 7/46] versus 2.4% [i.e. 3/126]). This difference was statistically significant (p= 0.011). Postoperative AKI was independently significantly associated with LOS (p= 0.001) and mortality (p=0.016) (Table 8). Among the 46 patients who developed postoperative AKI, 29(63.0%) were found to have recovered from AKI. Renal replacement therapy (RRT) was required in 4(8.7%) patients who had KDIGO grade III AKI. However, none of these patients received this form of treatment because they couldn't afford it.

Table 7: Association between postoperative AKI and outcomes (LOS & mortality)-results of univariate and multivariate analyses

Outcome variables	Postoperative AKI		Univariate analysis	Multivariate analysis
	AKI(n=46)	No AKI(n=126)	OR[95 CI];p-value	OR[95 CI];p-value
LOS				
<14	20(14.9)	114(85.1)	1	
≥14	26(68.4)	12(31.6)	12.3[5.3-28.4];<0.001	5.84[2.12-16.06]; 0.001
Survival				
Alive	39(24.1)	123(75.9)	1	
Dead	7(70.0)	3(30.0)	7.35[1.11-6.13];0.005	5.67[0.22-0.98];0.02

Discussion

Acute kidney injury (AKI) is a common postoperative complication, with incidence accounting for up to 40% of in-hospital AKI cases (Uchino., 2005). The incidence of AKI in this group of patients is variable, depending on the surgical setting and the AKI definition used, with the highest rates found after cardiac, general, and thoracic surgeries (Thakar.,2013; Grams *et al*., 2016). Studies have shown that the

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incidence of AKI following major abdominal surgery varied between 3.1 and 35.3% and showed considerable heterogeneity (Bellomo *et al*., 2004; Bellomo *et al*., 2012). In this study, the incidence of AKI was found to be 26.7%, which is low compared to a high AKI incidence of 39.3% reported by Bihorac *et al.* (2013) following major abdominal surgery. In comparison, Kim *et al. (*2013) examined AKI after abdominal surgery in a large multicenter study, reporting a rate of 1.1%. Patients who underwent explorative laparotomy had the highest AKI incidence, which is in line with our findings. Similarly, a study by Kheterpal *et al.* (2007) revealed an AKI rate of 1.0%. Interestingly, Teixeira *et al*. (2014) examined postoperative AKI after abdominal surgery using the KDIGO criteria and found an incidence of 22.4%, which is almost similar to the overall incidence in our study. This wide variability in the incidence of AKI in these studies may be related to the differences in case mix between studies and diagnostic criteria used to define AKI. For example, in our study, we used the KIDGO definition of AKI and only serum creatinine was used. In contrast, other components like eGFR and cystatin-C were used in other studies. Others evaluated simultaneously serum creatinine and urine output to define and categorize AKI, as recommended (Bellomo *et al*., 2004).

Recent studies have documented that detecting AKI using serum creatinine levels is problematic because serum creatinine levels are elevated after renal function has declined and does not reflect injury (Macedo., 2011; Macedo *et al*., 2015). Therefore, recent investigations have focused on finding practical serum and urine biomarkers to reveal early injury before profound functional damage occurs (Koyner *et al.,* 2013). The most promising marker includes plasma and urinary neutrophil gelatinase-associated lipocalin NGAL) (Koyner *et al.,* 2013). Also, the combination of urinary Kidney Injury Molecule-1 (KIM-1), *N*-acetyl-beta-d-glucosaminidase, and NGAL improved the sensitivity of early recognition of postoperative AKI when compared with individual biomarkers (Han et *al.,* 2009). Recently, tissue inhibitors of metalloproteinases-2 (TIMP-2) and insulin-like growth factor binding protein 7 (IGFBP7) have been validated as risk predictors for AKI (Meersch *et al*., 2014). Recently, some researchers have assessed combinations of two or more biomarkers to improve the diagnostic power for AKI. This approach is promising because different biomarkers indicate different aspects of renal injury (Meersch *et al*., 2014). The development of novel biomarkers may provide a more accurate and faster way of detecting postoperative AKI, which could eventually lead to earlier intervention. However, these biomarkers are limited in resource-limited settings due to unavailability and high costs. The high incidence of AKI in our study indicates a vast and as yet unrecognized burden of AKI among postoperative patients following major abdominal surgery in our local setting.

Some studies have investigated and identified several factors associated with the development of postoperative AKI (Bihorac *et al.,* 2013; Grams *et al*., 2016). As reported by Lugazia *et al.* (2022) in Dar es Salaam, Tanzania, this study found that AKI was 2.7 times more likely to occur in patients over 45 years than patients less than or equal to 45 years. This has been the trend in other parts of the world as well, with higher renal insults from trauma in the elderly of up to 3 to 6-fold (Coca., 2010; Rosner *et al*., 2013). Age-related changes, including structural and physiological changes, are greatly responsible for this. Changes which occur in the kidneys include a decrease in renal mass with ageing (Lindeman., 1990), loss of cortico-glumeruli due to ischemic changes, subclinical injury to the kidney from co-morbid conditions, reduction in the number and size of tubules, increasing tubulo-interstitial fibrosis and a decrease in glomerular filtering surface (Kaplan., 1975; Frocht & Fillit., 1984). Additionally, older patients are more often exposed to medications that can affect renal function, such as diuretics and contrast media (YIlmaz & Erdem., 2010). Pre-existing medical conditions, such as chronic kidney disease, diabetes mellitus, hypertension, cardiovascular disease, liver disease, and chronic obstructive pulmonary disease, are well-documented risk factors predisposing a patient to postoperative AKI (Raji *et al*., 2018). In this study, pre-existing medical illnesses, including diabetes mellitus, hypertension and peptic ulcer diseases, were observed to be associated with an increased risk of postoperative AKI by

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5.9-fold. This agrees with the observations by Raji *et al. (2018) in Nigeria,* who reported pre-existing medical illness as an independent risk factor for developing postoperative AKI. Biteker *et al.* (2011) reported a prevalence of 49% among patients who had hypertension and 30% in those having diabetes mellitus. Patients with more than one preexisting medical condition had more risk (Biteker *et al.,* 2011). There is a need to do a thorough preoperative evaluation of those patients to know their renal function status and optimize them before scheduling them for surgery. It is also imperative to weigh the risk a particular surgery carries, the type of pre-existing medical illness a patient has, and having a perioperative renal care plan. Also, further studies are needed to evaluate the exact risk of each particular disease in our settings

In this study, pre-existing kidney dysfunction (pre-existing elevated SCr) was identified as a predictor of AKI among our patients. However, we couldn't establish whether the pre-existing kidney dysfunction was chronic kidney disease (CKD) or AKI. This is because most patients had no baseline SCr records at least 3 months before admission for the surgical procedures. The existence of pre-existing kidney dysfunction in our study increased the risk of developing postoperative AKI by 3.8-fold. This finding is in keeping with previous reports that classified CKD as a risk factor for AKI (Singh *et al*., 2010). Although CKD may not be reversible, prompt identification of modifiable postoperative risk factors for AKI and instituting preventive measures may safeguard against the development of AKI, which is a known risk factor for CKD progression. Also, the early involvement of nephrologists in the optimal care of at-risk patients prior to surgery will go a long way in reducing the burden of AKI among individuals undergoing surgical interventions.

The timing of surgery has been reported to have a significant effect on the risk of postoperative AKI occurrence (Biteker *et al.,* 2011; Raji *et al*., 2018). The risk of postoperative AKI is increased in emergency surgery versus elective operations (Raji *et al*., 2018). In the present study, patients who underwent emergency surgery were more likely to develop AKI compared to those who underwent elective surgery. This finding is in keeping with a Nigerian study by Raji *et al. (2018), who reported similar observations but contrary to Lugazia et al. (2018) in Tanzania, who found no statistically significant association between emergency surgery and the* development of AKI. This association between emergency surgery and post-operative AKI reflects that most emergency surgeries are done to restore physiological function or save lives. Thus, there is little time to evaluate or optimize the patients before surgery.

In the current study, the duration of surgery > 2 hours was found to be associated with an increased risk of postoperative AKI. This agrees with other studies by Raji *et al. (2018) in Nigeria and Deng et al.* (2017) in China. Raji *et al. (2018) found that among those surgeries that* took more than 2 hours, the incidence of peri-operative AKI was 65.3%. Therefore, good patient preparation for those surgeries that take extended time or are presumed to be prolonged, together with close intra-operative monitoring and surveillance, is vital to minimize the risk. For surgery lasting >120 min, adequate fluid balance both prior to and during surgery must be ensured, in addition to optimal BP control to prevent episodes of intra-op hypotension and hypertension. These steps will reduce the risk of AKI in patients undergoing abdominal surgery.

Various studies have documented the deleterious impact of AKI on the early outcomes of patients (Bihorac *et al.,* 2013; Grams *et al*., 2016). Postoperative AKI remains a leading cause of morbidity, mortality, prolonged hospital stays, and increased hospital costs (Chertow *et al*., 2005; Neves *et al*., 2015). The influence of postoperative AKI on prolonged length of hospital stay has been demonstrated after abdominal surgery (Chertow *et al*., 2005). In the present study, postoperative AKI was statistically significantly associated with a more extended hospital stay. This is in keeping with reports from other studies (Chertow *et al*., 2005; Neves *et al*., 2015). In a retrospective study of 595 patients by Lee *et al.* (2014), it was found that the extent of hospital stay following abdominal surgery was significantly

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longer in patients with AKI. Similarly, Tomozawa *et al*. (2015) reported that AKI after liver resection surgery was correlated with prolonged length of stay, increased rates of artificial ventilation, need for re-intubation, and requirement for renal replacement therapy. In a retrospective study by Kim *et al*. (2013), gastric surgery patients with AKI had significantly more extended hospital stays and a higher prevalence of intensive care unit admission after the operation.

In this study, the mortality rate among patients with AKI was 15.2%, a figure which is comparable to the 10% that was reported by Lugazia et al. (2022) in Dar Es Salaam, Tanzania. Several studies have demonstrated a mortality rate in patients with AKI ranging between 10-20% (Olowu *et al.,* 2016), which is comparable to a figure which was observed in our patients who developed AKI. The finding that post-operative AKI is a strong predictor of in-hospital mortality following abdominal surgery is well documented in the literature (Kim *et al*. (2013; Tomozawa *et al*., 2015) as well as in the current study. In a retrospective study of 4718 gastric surgery patients, Kim *et al. (2013) found that the in-hospital mortality for patients with AKI was* significantly higher than that for patients without AKI. In another retrospective analysis of 642 liver resection patients by Tomozawa *et al*. (2015), AKI was associated with increased mortality. In a study by Teixeira *et al.* (2014), 450 primary abdominal surgery patients were retrospectively studied, and postoperative AKI was independently associated with increased in-hospital mortality.

Renal recovery after AKI is essential for patients, families, and stakeholders. Several studies have reported renal recovery rates between 17 and 84% (Kim *et al., 2013*; Lugazia *et al*., 2022). Our study shows a 63.0% recovery rate at hospital discharge and during follow-up based on serum creatinine results. This is comparable to the renal recovery of 60% that was reported by Lugazia et al. (2022) in Dar es Salaam, Tanzania. Despite a good proportion of the subjects recovering from AKI, those with severe AKI usually require temporary Renal Replacement Therapy. None of our patients who developed post-operative AKI underwent temporary RRT. Those who do not recover may end up with chronic renal failure and require long-term RRT or death in the event of complications or lack of access to this life-sustaining therapy due to economic hardships (Injury *et al.,* 2014). These observed outcomes and anticipated social, economic, and health impact of post-operative AKI on quality of life call for deliberate efforts to prevent and aggressively treat peri-operative AKI.

The strengths of this study are the relatively large sample size and the use of recent and validated AKI definitions for assessing clinical outcomes. However, this study has several limitations. First, findings from this study cannot be generalized to the rest of the population as it is single-centred and time-limited. Second, only serum creatinine was used to define AKI, which may not detect early renal dysfunction, and this may have resulted in an underestimation of the incidence of AKI. Third, due to the nature and reality of patients, there was missing information from some subjects that caused a dropout from this study despite initial enrolment.

In conclusion, this study demonstrated a high incidence of predicting factors for AKI among patients undergoing major abdominal surgery at BMC. The cumulative incidence of AKI was high and independently associated with the patient's age, pre-existing medical illness, pre-existing renal dysfunction, duration of surgery and emergency surgery. Most of these factors are preventable/modifiable; thus, a strong follow-up and adherence to standard operating procedures and multidisciplinary care of patients can help reduce the incidence and provide good care for the affected individuals. The presence of AKI increased the mortality rate and length of hospital stay among patients undergoing major abdominal surgery. Renal recovery was observed in approximately two-thirds of those who developed postoperative AKI. None of our grade 3 AKI patients who required temporary renal replacement therapy (RRT) received such a modality of treatment. It is therefore recommended that: -

- Prompt identification and aggressive treatment of AKI risk factors following abdominal surgery in order to reduce the burden of AKI in this group of patients.
- Temporary RRT should be made available to all patients in acute status
- A similar study should be conducted to involve all general surgical patients undergoing major surgery at BMC for a more extended follow-up and a larger sample size

Ethical considerations

This study adhered to the Joint CUHAS-Bugando/BMC Research Ethics and Review Committee (CREC) requirements, and ethical approval to conduct the study was sought from the committee **(ethical clearance number CREC/537/2022)** before the commencement of the study. Permission to conduct the study was obtained from the hospital authority (BMC) where the study was conducted. Enrolled patients were required to sign a written informed consent for the study and HIV testing. Patients were assured that the information collected would be maintained under strict confidentiality. The study did not interfere with the attending doctors' decision, and the patient's refusal to consent or withdraw from the study did not alter or jeopardize their access to medical services.

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References

Bellomo, R., Kellum, J.A., Ronco, C. (2012) Acute kidney injury. *Lancet* 380, 756–66

Bellomo, R., Ronco, C., Kellum, J.A., Mehta, R.L., Palevsky, P. (2004) Acute Dialysis Quality Initiative workgroup. Acute renal failure—definition, outcome measures, animal models, fluid therapy and information technology needs: The Second International Consensus Conference of the Acute Dialysis Quality Initiative (ADQI) Group. *Critical Care* 8, 204–12

Bihorac, A., Brennan, M., Ozrazgat-Baslanti, T., Bozorgmehri, S., Efron, P.A., Moore, F.A., Segal, M.S., Hobson, C.E. (2013) National surgical quality improvement program underestimates the risk associated with mild and moderate postoperative acute kidney injury. *Critical Care Medicine* 41, 2570–2583.

Biteker, M., Biteker, F., Duman, D., Dayan, A. (2011) Predictors of perioperative renal failure after noncardiac, nonvascular surgery in patients with previously normal renal function. *European Heart Journal* 32, 849.

Cerdá, J., Mohan, S., Garcia-Garcia, G., et al. (2017) Acute kidney injury recognition in low- and middle-income countries. *Kidney International Reports* 2, 530–543.

Chertow, G.M., Burdick, E., Honour, M., Bonventre, J.V., Bates, D.W. (2005) Acute kidney injury, mortality, length of stay, and costs in hospitalized patients. *Journal of American Society of Nephrology* 16, 3365–70.

Coca, S.G. (2010) Acute kidney injury in elderly persons. *American Journal of Kidney Disease* 56,122–31

Deng, Y., Yuan, J., Chi, R., Ye, H., Zhou, D., et al. (2017) The Incidence, Risk Factors and Outcomes of Postoperative Acute Kidney Injury in Neurosurgical Critically Ill Patients. *Scientific Report* 7, 1-9.

Frocht, A., Fillit, H. (1984) Renal disease in the geriatric patient. *Journal of American Geriatrics Society* 32, 28–43.

Grams, M.E., Sang, Y., Coresh, J., Ballew, S., Matsushita, K., Molnar, M.Z., Szabo, Z., Kalantar-Zadeh, K., Kovesdy, C.P. (2016) Acute kidney injury after major surgery: A retrospective analysis of veterans health administration data. *American Journal of Kidney Disease* 67, 872–880.

Han, W.K., Wagener, G., Zhu, Y., Wang, S., Lee, H.T. (2009) Urinary biomarkers in the early detection of acute kidney injury after cardiac surgery. *Clinical Journal of American Society of Nephrology* 4, 873–82.

Initiative workgroup. (2004) Acute renal failure—definition, outcome measures, animal models, fluid therapy and information technology needs: The Second International Consensus Conference of the Acute Dialysis Quality Initiative (ADQI) Group. *Critical Care* 8, 204–12

Jha, V., Parameswaran, S. (2013) Community-acquired acute kidney injury in tropical countries. *Nature Reviews Nephrology* 9, 278–290.

Kaplan, C., Pasternack, B., Shah, H., Gallo, G. (1975) Age-related incidence of sclerotic glomeruli in human kidneys. *American Journal of Pathology* 80, 227–34.

Kheterpal, S., Tremper, K.K., Englesbe, M.J., O'Reilly, M., Shanks, A.M., Fetterman, D.M. Rosenberg, A.L., Swartz, R.D. (2007) Predictors of postoperative acute renal failure after noncardiac surgery in patients with previously normal renal function. *Anesthesiology* 107, 892–902.

Acute Kidney Injury Work Group. (2012): Kidney Disease Improving Global Outcomes (KDIGO) clinical practice guideline for acute kidney injury. *Kidney International* 2, 1–138.

Kim, C.S., Oak, C.Y., Kim, H.Y., Kang, Y.U., Cho,i JS., Bae, E.U.., Ma, S.K., Kweon, S.S., Kim, S.W. (2013) Incidence, Predictive Factors, and Clinical Outcomes of Acute Kidney Injury after Gastric Surgery for Gastric Cancer. *PLoS ONE* 8, e82289.

Koyner, J.L., Parikh, C.R. (2013) Clinical utility of biomarkers of AKI in cardiac surgery and critical illness. *Clinical Journal of American Society of Nephrology* 8, 1034–42

Lee, E.H., Kim, H.R., Baek, S.H., Kim, K.M., Chin, J.H., Choi, D.K., Kim, W.J., Choi, I.C. (2014) Risk factors of postoperative acute kidney injury in patients undergoing esophageal cancer surgery. *Journal of Cardiothorac Vascular and Anesthesia* 28, 948–54.

Lewington, A., Cerdá, J., Mehta, R. (2013) Raising awareness of acute kidney injury: a global perspective of a silent killer. *Kidney International* 84, 457–67.

Lindeman, R.D. (1990) Overview: renal physiology and pathophysiology of aging. *American Journal of Kidney Disease* 16, 275–82.

Lugazia, E., Kaniki, I.R., Mbanga, F., Boniface, R., Furia, F. (2022) Prevalence of Post-Operative Acute Kidney Injury and Associated Risk Factors at A Tertiary Trauma Center in Dar es Salaam, Tanzania. *Journal of Surgery* 7, 1481

Macedo, E. (2015) Urine output assessment as a clinical quality measure. *Nephron* 131, 252–4.

Macedo, E., Malhotra, R., Bouchard, J., Wynn, S., Mehta, R. (2011) Oliguria is an early predictor of higher mortality in critically ill patients. *Kidney International* 80, 760–7.

Meersch, M., Schmidt, C., Van Aken, H., Martens, S., Rossaint, J., Singbartl, K. et al (2014) Urinary TIMP-2 and IGFBP7 as early biomarkers of acute kidney injury and renal recovery following cardiac surgery. *PLoS ONE* 9, e93460

Mehta, R.L., Kellum, J.A., Shah, S.V., Molitoris, B.A., Ronco, C., Warnock, D.G., Levin, A. (2007) Acute kidney injury network: Report of an initiative to improve outcomes in acute kidney injury. *Critical Care* 11, 31.

Melo, FdAF., Macedo, E., Fonseca-Bezerra, A.C., Melo WALd., Mehta, R.L., Burdmann, EdA., Trevisan-Zanetta, D.M. (2020) A systematic review and meta-analysis of acute kidney injury in the intensive care units of developed and developing countries. *PLoS ONE* 15, e0226325.

Neves, J.B., Jorge, S., Lopes, J.A. (2015) Acute kidney injury: epidemiology, diagnosis, prognosis, and future directions. *EMJ Nephrology* 3, 90–6.

Olowu, W., Niang, A., Osafo, C., Ashuntantang, G., Arogundade, F.A., Porter, J., Naicker, S., Luyckx, V.A. (2016) Outcomes of Acute Kidney Injury in Children and Adults in Sub-Saharan Africa: A Systematic Review. *The Lancet Global Health*, 4, e242-e250.

Priyamvada, P.S., Jayasurya, R., Shankar, V., Parameswaran, S. (2018) Epidemiology and outcomes of acute kidney injury in critically ill: Experience from a tertiary care center. *Indian Journal of Nephrology* 28, 413-20

Raji, Y.R., Ajayi, S.O., Ademola, A.F., Lawal, T.A., Ayandipo, O.O., Adigun, T., Salako, B. (2018) Acute kidney injury among adult patients undergoing major surgery in a tertiary hospital in Nigeria. *Clincal Kidney Journal* 11, 443-449.

Rosner, M.H. (2013) Acute kidney injury in the elderly. *Clinical Geriatrics Medicine* 29, 565–78.

Singh, P., Rifkin, D.E., Blantz, R.C. (2010) Chronic kidney disease: an inherent risk factor for acute kidney injury? *Clinical Journal of American Society of Nephrology* 5, 1690–1695

Teixeira, C., Rosa, R., Rodrigues, N., Mendes, I., Peixoto, L., Dias, S., Melo, M.J., Pereira, M., Bicha-Castelo, H., Lopes, J.A. (2014) Acute kidney injury after major abdominal surgery: a retrospective cohort analysis. *Critical care Research and Practice* 2014: 132175

Thakar, C.V. (2013) Perioperative acute kidney injury. *Advanced Chronic Kidney Disease* 20, 67–75.

Tomozawa, A., Ishikawa, S., Shiota, N., Cholvisudhi, P., Makita, K. (2015) Perioperative risk factors for acute kidney injury after liver resection surgery: an historical cohort study. *Canadian Journal of Anaesthesia* 62, 753–61

Uchino, S. (2005) Acute renal failure in critically Ill patients. A multinational, multicenter study. *JAMA* 294, 813

Wierstra, B.T., Kadri, S., Alomar, S., Burbano, X., Barrisford, G.W., Kao, R.L. (2016) The impact of “early” versus “late” initiation of renal replacement therapy in critical care patients with acute kidney injury: a systematic review and evidence synthesis. *Critical Care* 20, 122.

YIlmaz, R., Erdem, Y. (2010) Acute kidney injury in the elderly population. *International Urology and Nephrology* 42, 259–71.